Centre DE Nanosciences & DE Nanotechnologies

M2 Internship offer 2023/2024

Departement/Team: Photonique/ODIN
Person in charge of the internship: A. Bousseksou / R. Colombelli
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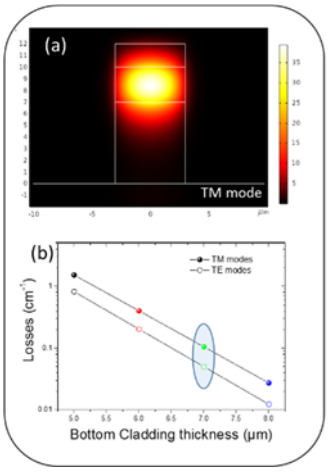
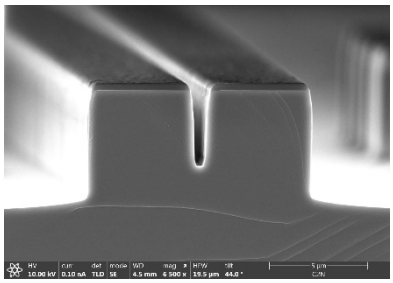
Integrated Mid-IR photonics: High quality factor resonators

Scientific project: Applications relying on mid-infrared radiation (MIR, λ = 3-12 µm) have progressed at a rapid pace recently, stimulated by scientific and technological breakthroughs. For instance MIR cameras have enabled thermal imaging and the invention of the quantum cascade laser (QCL) has enabled a vast range of applications in spectroscopy, metrology, medicine. In addition to the generation and detection of light, a key functionality for most photonic systems is the possibility to electrically control the amplitude, phase, and polarization of a laser beam up to ultrashort time scales. Contrary to the visible and near-IR range, in the MIR range passive or active integrated components such as modulators and directional couplers do not exist, but recent experiments [1] have revealed propagation losses less that 1dB/cm at λ=5.2µm. In this context, the host team has recently developed passive integrated waveguides on III-V semicondutor plaforms (InGaAs/InP and AlGaAs/GaAs), and identified **the opportunity of greatly improving the propagation losses at longer wavelengths.**



But du stage/internship objectives: The goal of the internship is to develop mid-infrared integrated optical resonators based on a low loss integrated waveguide geometry. The perspective student will perform the design of the optical cavities such as ring or racetrack resonators. The material systems that will be investigated are GaAs/AlGaAs-on-GaAs and InGaAs/InP-on-InP. The subtle design of optical waveguide features such as optical refractive index contrast, free carrier absorption and geometric parameters will be a primordial element that will be taken into account. Operation will be optimized for the 8-9 µm wavelength range, in the center of an atmospheric transparency region. The sample characterizations will take place with a dedicated end fire coupling setup equipped with a variety of mid-IR laser sources (allowing to control the injected wavelength, power and polarization) and detectors. She/he will benefit from the experience of the host team (https://odin.c2n.universite-paris-saclay.fr/en/activities/mir-thz-devices/) in quantum and electromagnetic design of opto-electronic devices, of cleanroom fabrication, and device opto-electronic characterizations [2].



Qualités du candidat(e) requises/ required skills: Basic knowledge in optics and electromagnetics, semiconductor physics, optoelectronics, ability to work in groups, interest for experimental work.

Relevant References:[1] Kevin Zhang, Gerhard Böhm, Mikhail A. Belkin; Mid-infrared microring resonators and optical waveguides on an InP platform. Appl. Phys. Lett. 7 February 2022; 120 (6): 061106. https://doi.org/10.1063/5.0077394

[2] S. Pirotta *et al.*, *"Fast amplitude modulation up to 1.5 GHz of mid-IR free-space beams at room-temperature*", Nat. Commun. 12, 799 (2021). https://www.nature.com/articles/s41467-020-20710-2

Methods and techniques: Numerical modeling of the optical properties of waveguide and inter-sub-band-transition in semiconductor heterostructure. Optical characterization, optoelectronic characterization techniques. During the internship student may follow cleanroom fabrication of devices.

Possibility to go on with a PhD ? YES

Envisaged fellowship ? Doctoral school or research grant

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